

United States
Environmental Protection
Agency

Office of Water Program
Operations
Washington DC 20460

Office of Research and
Development
Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Technology Transfer



Design Manual

Onsite Wastewater Treatment and Disposal Systems

EPA 625/1-80-012

DESIGN MANUAL

ONSITE WASTEWATER TREATMENT
AND DISPOSAL SYSTEMS

U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Water Program Operations

Office of Research and Development
Municipal Environmental Research Laboratory

October 1980

NOTICE

The mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the U. S. Environmental Protection Agency.

FOREWORD

Rural and suburban communities are confronted with problems that are unique to their size and population density, and are often unable to superimpose solutions typically applicable to larger urban areas. A good example of such problems is the provision of wastewater services.

In the past, priorities for water pollution control focused on the cities, since waste generation from these areas was most evident. In such high-density development, the traditional sanitary engineering approach was to construct a network of sewers to convey wastewater to a central location for treatment and disposal to surface waters. Since a large number of users existed per unit length of sewer line, the costs of construction and operation could be divided among many people, thus keeping the financial burden on each user relatively low.

Within the past several decades, migration of the population from cities to suburban and rural areas has been significant. With this shift came the problems of providing utility services to the residents. Unfortunately, in many cases, solutions to wastewater problems in urban areas have been applied to rural communities. With the advent of federal programs that provide grants for construction of wastewater facilities, sewers and centralized treatment plants were constructed in these low-density rural settings. In many cases the cost of operating and maintaining such facilities impose severe economic burdens on the communities.

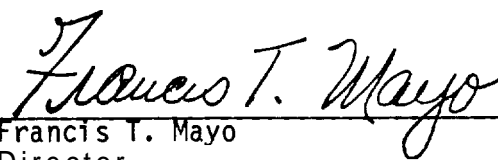
Although wastewater treatment and disposal systems serving single homes have been used for many years, they have often been considered an inadequate or temporary solution until sewers could be constructed. However, research has demonstrated that such systems, if constructed and maintained properly, can provide a reliable and efficient means of wastewater treatment and disposal at relatively low cost.

This document provides technical information on onsite wastewater treatment and disposal systems. It does not contain standards for those systems, nor does it contain rules or regulations pertaining to onsite systems.

The intended audience for this manual includes those involved in the design, construction, operation, maintenance, and regulation of onsite wastewater systems.



Henry L. Longest
Deputy Assistant Administrator
for Water Program Operations



Francis T. Mayo
Director
Municipal Environmental
Research Laboratory

ACKNOWLEDGMENTS

There were three groups of participants involved in the preparation of this manual : (1) the contractor-authors, (2) the contract supervisors, and (3) the technical reviewers. The manual was written by personnel from SCS Engineers and Rural Systems Engineering (RSE). Contract supervision was provided by U.S. Environmental Protection Agency (EPA) personnel from the Municipal Construction Division in Washington, D.C. , and from the Municipal Environmental Research Laboratory in Cincinnati, Ohio. The technical reviewers were experts in certain areas of onsite waste treatment and disposal , and included professors, health officials, consultants, and government officials. Each provided technical review of a section or sections of the report. The membership of each group is listed below.

CONTRACTOR-AUTHORS:

Direction: Curtis J. Schmidt, SCS
William C. Boyle, RSE

Senior Authors: Ernest V. Clements, Project Manager, SCS
Richard J. Otis, RSE

Contributing Authors: David H. Bauer, SCS
Robert L. Siegrist, E. Jerry Tyler,
David E. Stewart, James C. Converse, RSE

CONTRACT SUPERVISORS:

Project Officers: Robert M. Southworth, OWPO, EPA, Washington, D.C.
Robert P. G. Bowker, MERL, EPA, Cincinnati, Ohio

Reviewers: James Kreissl, MERL , EPA, Cincinnati , Ohio
Denis Lussier, CERL, EPA, Cincinnati, Ohio
Sherwood Reed, CRREL, COE, Hanover, N.H.

TECHNICAL REVIEWERS:

1. Michael Hansel - Minnesota Pollution Control Agency
2. Roger Machmeier - University of Minnesota
3. Jack Abney - Parrott, Ely & Hurt, Inc., Lexington, Kentucky
4. William Mellen - Lake County Health Department, Illinois
5. Rein Laak - University of Connecticut
6. Gary Plews - Washington Department of Social & Health Services
7. B. L. Carlile - North Carolina State University
8. John Clayton - Fairfax County Health Department, Virginia
9. William Sharpe - Pennsylvania State University
10. Elmer Jones - U.S. Department of Agriculture
11. Edwin Bennett - University of Colorado
12. Harry Pence - Virginia Polytechnic Institute
13. Briar Cook - U.S. Department of Agriculture, Forest Service
14. Marek Brandes - Ontario Ministry of the Environment (Retired)
15. Michael Hines - Illinois State Department of Public Health
16. John Fancy - John Fancy, Inc. , Waldoboro, Maine

CONTENTS

<u>Chapter</u>		<u>Page</u>
	FORWORD	iii
	ACKNOWLEDGEMENTS	v
	CONTENTS	vii
	LIST OF FIGURES	ix
	LIST OF TABLES	xv
1	INTRODUCTION	
	1.1 Background	1
	1.2 Purpose	2
	1.3 Scope	3
2	STRATEGY FOR ONSITE SYSTEM DESIGN	
	2.1 Introduction	4
	2.2 Onsite System Design Strategy	4
3	SITE EVALUATION PROCEDURES	
	3.1 Introduction	13
	3.2 Disposal Alternatives	13
	3.3 Site Evaluation Strategy	17
	3.4 References	48
4	WASTEWATER CHARACTERISTICS	
	4.1 Introduction	50
	4.2 Residential Wastewater Characteristics	50
	4.3 Nonresidential Wastewater Characteristics	57
	4.4 Predicting Wastewater Characteristics	65
	4.5 References	68
5	WASTEWATER MODIFICATION	
	5.1 Introduction	70
	5.2 Water Conservation and Wastewater Flow Reduction	71
	5.3 Pollutant Mass Reduction	84
	5.4 Onsite Containment - Holding Tanks	88
	5.5 Reliability	88
	5.6 Impacts on Onsite Treatment and Disposal Practices	92
	5.7 References	95

CONTENTS (continued)

<u>Chapter</u>		<u>Page</u>
6	ONSITE TREATMENT METHODS	
	6.1 Introduction	97
	6.2 Septic Tanks	98
	6.3 Intermittent Sand Filters	113
	6.4 Aerobic Treatment Units	140
	6.5 Disinfection	161
	6.6 Nutrient Removal	184
	6.7 Waste Segregation and Recycle Systems	197
	6.8 References	199
7	DISPOSAL METHODS	
	7.1 Introduction	206
	7.2 Subsurface Soil Absorption	207
	7.3 Evaporation Systems	300
	7.4 Outfall to Surface Waters	316
	7.5 References	316
8	APPURTENANCES	
	8.1 Introduction	321
	8.2 Grease Traps	321
	8.3 Dosing Chambers	327
	8.4 Flow Diversion Methods for Alternating Beds	335
	8.5 References	337
9	RESIDUALS DISPOSAL	
	9.1 Introduction	338
	9.2 Residuals Characteristics	338
	9.3 Residuals Handling Option	343
	9.4 Ultimate Disposal of Septage	343
	9.5 References	351
10	MANAGEMENT OF ONSITE SYSTEMS	
	10.1 Introduction	353
	10.2 Theory of Management	354
	10.3 Types of Management Entities	355
	10.4 Management Program Functions	358
	10.5 References	366
	APPENDIX - Soil Properties and Soil-Water Relationships	367
	GLOSSARY	382

FIGURES

<u>Number</u>		<u>Page</u>
2-1	Onsite Wastewater Management Options	5
2-2	Onsite System Design Strategy	7
3-1	Potential Evaporation Versus Mean Annual Precipitation	16
3-2	Example of a Portion of a Soil Map as Published in a Detailed Soil Survey (Actual Size)	20
3-3	Translation of Typical Soil Mapping Unit Symbol	20
3-4	Plot Plan Showing Soil Series Boundaries from Soil Survey Report	23
3-5	Plot Plan Showing Surface Features	25
3-6	Landscape Positions	27
3-7	Methods of Expressing Land Slopes	27
3-8	Preparation of Soil Sample for Field Determination of Soil Texture	30
3-9	Soil Texture Determination by Hand: Physical Appearance of Various Soil Textures	32
3-10	Comparison of Ribbons and Casts of Sandy Loam and Clay (Ribbons Above, Casts Below)	33
3-11	Example Procedure for Collecting Soil Pit Observation Information	34
3-12	Types of Soil Structure	36
3-13	Typical Observation Well for Determining Soil Saturation	38
3-14	Construction of a Percometer	42
3-15	Percolation Test Data Form	43
3-16	Compilation of Soils and Site Information (Information Includes Topographic, Soil Survey, Onsite Slope and Soil Pit Observations)	45

FIGURES (continued)

<u>Number</u>		<u>Page</u>
4-1	Frequency Distribution for Average Daily Residential Water Use/Waste Flows	53
4-2	Peak Discharge Versus Fixture Units Present	64
4-3	Strategy for Predicting Wastewater Characteristics	67
5-1	Example Strategies for Management of Segregated Human Wastes	89
5-2	Example Strategies for Management of Residential Graywater	89
5-3	Flow Reduction Effects on Pollutant Concentrations	93
6-1	Typical Septic Tank Outlet Structures to Minimize Suspended Solids in Discharge	105
6-2	Septic Tank Scum and Sludge Clear Spaces	107
6-3	Typical Two-Compartment Septic Tank	108
6-4	Four Precast Reinforced Concrete Septic Tanks Combined into One Unit for Large Flow Application	114
6-5	Typical Buried Intermittent Filter Installation	129
6-6	Typical Free Access Intermittent Filter	131
6-7	Typical Recirculating Intermittent Filter System	134
6-8	Recirculation Tank	134
6-9	By-Pass Alternatives for Recirculating Filters	135
6-10	Aerobic and Anaerobic Decomposition Products	142
6-11	Examples of Extended Aeration Package Plant Configurations	144
6-12	Examples of Fixed Film Package Plant Configurations	156
6-13	Stack Feed Chlorinator	171

FIGURES (continued)

<u>Number</u>		<u>Page</u>
6-14	Iodine Saturator	172
6-15	Sample Contact Chamber	174
6-16	Typical UV Disinfection Unit	177
6-17	Typical UV Sterilizing Chamber	178
6-18	Onsite Denitrification Systems	190
7-1	Typical Trench System	209
7-2	Typical Bed System	210
7-3	Alternating Trench System with Diversion Valve	218
7-4	Provision of a Reserve Area Between Trenches of the Initial System on a Sloping Site	220
7-5	Trench System Installed to Overcome a Shallow Water Table or Restrictive Layer	222
7-6	Typical Inspection Pipe	228
7-7	Backhoe Bucket with Removable Raker Teeth	228
7-8	Methods of Soil Absorption Field Rehabilitation	232
7-9	Seepage Pit Cross Section	236
7-10	Typical Mound Systems	240
7-11	Detailed Schematic of a Mound System	241
7-12	Proper Orientation of a Mound System on a Complex Slope	246
7-13	Mound Dimensions	247
7-14	Tiered Mound System	257
7-15	Curtain Drain to Intercept Laterally Moving Perched Water Table Caused by a Shallow, Impermeable Layer	261

FIGURES (continued)

<u>Number</u>		<u>Page</u>
7-16	Vertical Drain to Intercept Laterally Moving Perched Water Table Caused by a Shallow, Thin, Impermeable Layer	261
7-17	Underdrains Used to Lower Water Table	262
7-18	Typical Electro-Osmosis System	270
7-19	Single Line Distribution Network	273
7-20	Drop Box Distribution Network	274
7-21	Closed Loop Distribution Network	276
7-22	Distribution Box Network	277
7-23	Relief Line Distribution Network	279
7-24	Central Manifold Distribution Network	280
7-25	End Manifold Distribution Network	281
7-26	Lateral Detail - Tee to Tee Construction	282
7-27	Lateral Detail - Staggered Tees or Cross Construction	283
7-28	Required Lateral Pipe Diameters for Various Hole Diameters, Hole Spacings, and Lateral Lengths (for Plastic Pipe Only)	285
7-29	Recommended Manifold Diameters for Various Manifold Lengths, Number of Laterals, and Lateral Discharge Rates (for Plastic Pipe Only)	286
7-30	Nomograph for Determining the Minimum Dose Volume for a Given Lateral Diameter, Lateral Length, and Number of Laterals	287
7-31	Distribution Network for Example 7-2	289
7-32	Distribution Network for Example 7-3	294
7-33	Schematic of a Leaching Chamber	298

FIGURES (continued)

<u>Number</u>		<u>Page</u>
7-34	Use of Metal Holders for the Laying of Flexible Plastic Pipe	299
7-35	Cross Section of Typical ET Bed	302
7-36	Curve for Establishing Permanent Home Loading Rate for Boulder, Colorado Based on Winter Data, 1976-1977	307
7-37	Typical Evaporation/Filtration Lagoon for Small Installations	312
8-1	Double-Compartment Grease Trap	326
8-2	Typical Dosing Chamber with Pump	329
8-3	Level Control Switches	331
8-4	Typical Dosing Chamber with Siphon	333
8-5	Typical Diversion Valve	335
8-6	Top View of Diversion Box Utilizing a Treated Wood Gate	336
8-7	Section View of Diversion Box Utilizing Adjustable Ells	336
A-1	Names and Size Limits of Practical-Size Classes According to Six Systems	368
A-2	Textural Triangle Defining Twelve Textural Classes of the USDA (Illustrated for a Sample Containing 37% Sand, 45% Silt, and 18%Clay)	370
A-3	Schematic Diagram of a Landscape and Different Soils Possible	375
A-4	Upward Movement by Capillarity in Glass Tubes as Compared with Soils	377
A-5	Soil Moisture Retention for Four Different Soil Textures	378

FIGURES (continued)

<u>Number</u>		<u>Page</u>
A-6	Hydraulic Conductivity (K) Versus Soil Moisture Retention	379
A-7	Schematic Representation of Water Movement Through a Soil with Crusts of Different Resistances	381

TABLES

<u>Number</u>		<u>Page</u>
2-1	Selection of Disposal Methods Under Various Site Constraints	9
3-1	Suggested Site Evaluation Procedure	18
3-2	Soil Limitations Ratings Used by SCS for Septic Tank/Soil Absorption Fields	22
3-3	Soil Survey Report Information for Parcel in Figure 3-4	24
3-4	Textural Properties of Mineral Soils	31
3-5	Grades of Soil Structure	36
3-6	Description of Soil Mottles	37
3-7	Estimated Hydraulic Characteristics of Soil	39
3-8	Falling Head Percolation Test Procedure	41
4-1	Summary of Average Daily Residential Wastewater Flows	52
4-2	Residential Water Use by Activity	54
4-3	Characteristics of Typical Residential Wastewater	56
4-4	Pollutant Contributions of Major Residential Wastewater Fractions (gm/cap/day)	58
4-5	Pollutant Concentrations of Major Residential Wastewater Fractions (mg/l)	58
4-6	Typical Wastewater Flows from Commercial Sources	60
4-7	Typical Wastewater Flows from Institutional Sources	61
4-8	Typical Wastewater Flows from Recreational Sources	62
4-9	Fixture-Units per Fixture	63
5-1	Example Wastewater Flow Reduction Methods	72

TABLES (continued)

<u>Number</u>		<u>Page</u>
5-2	Wastewater Flow Reduction - Water Carriage Toilets and Systems	74
5-3	Wastewater Flow Reduction - Non-Water Carriage Toilets	77
5-4	Wastewater Flow Reduction - Bathing Devices and Systems	79
5-5	Wastewater Flow Reduction - Miscellaneous Devices and Systems	82
5-6	Wastewater Flow Reduction - Wastewater Recycle and Reuse Systems	85
5-7	Example Pollutant Mass Reduction Methods	87
5-8	Additional Considerations in the Design, Installation and Operation of Holding Tanks	90
5-9	Potential Impacts of Wastewater Modification on Onsite Disposal Practices	94
6-1	Summary of Effluent Data from Various Septic Tank Studies	100
6-2	Typical Septic Tank Liquid Volume Requirements	103
6-3	Location of Top and Bottom of Outlet Tee or Baffle	107
6-4	Performance of Buried Intermittent Filters - Septic Tank Effluent	121
6-5	Performance of Free Access Intermittent Filters	122
6-6	Performance of Recirculating Intermittent Filters	123
6-7	Design Criteria for Buried Intermittent Filters	124
6-8	Design Criteria for Free Access Intermittent Filters	126
6-9	Design Criteria for Recirculating Intermittent Filters	128
6-10	Operation and Maintenance Requirements for Buried Intermittent Filters	138

TABLES (continued)

<u>Number</u>		<u>Page</u>
6-11	Operation and Maintenance Requirements for Free Access Intermittent Filters	138
6-12	Operation and Maintenance Requirements for Recirculating Intermittent Filters	139
6-13	Summary of Effluent Data from Various Aerobic Unit Field Studies	146
6-14	Typical Operating Parameters for Onsite Extended Aeration Systems	151
6-15	Suggested Maintenance for Onsite Extended Aeration Package Plants	153
6-16	Operational Problems - Extended Aeration Package Plants	154
6-17	Typical Operating Parameters for Onsite Fixed Film Systems	158
6-18	Suggested Maintenance for Onsite Fixed Film Package Plants	160
6-19	Operational Problems - Fixed Film Package Plants	162
6-20	Selected Potential Disinfectants for Onsite Application	163
6-21	Halogen Properties	164
6-22	Chlorine Demand of Selected Domestic Wastewaters	165
6-23	Performance of Halogens and Ozone at 25°C	167
6-24	Halogen Dosage Design Guidelines	168
6-25	UV Dosage for Selected Organisms	180
6-26	Potential Onsite Nitrogen Control Options	186
6-27	Potential Onsite Phosphorus Removal Options	194
6-28	Phosphorus Adsorption Estimates for Selected Natural Materials	198

TABLES (continued)

<u>Number</u>		<u>Page</u>
7-1	Site Criteria for Trench and Bed Systems	212
7-2	Recommended Rates of Wastewater Application for Trench and Bed Bottom Areas .	214
7-3	Typical Dimensions for Trenches and Beds	221
7-4	Dosing Frequencies for Various Soil Textures	224
7-5	Methods of Wastewater Application for Various System Designs and Soil Permeabilities	225
7-6	Sidewall Areas of Circular Seepage Pits (ft ²)	237
7-7	Site Criteria for Mound Systems	242
7-8	Commonly Used Fill Materials and their Design Infiltration Rates	245
7-9	Dimensions for Mound Systems	248
7-10	Infiltration Rates for Determining Mound Basal Area	249
7-11	Drainage Methods for Various Site Characteristics	266
7-12	Distribution Networks for Various System Designs and Application Methods	271
7-13	Discharge Rates for Various Sized Holes at Various Pressures (gpm)	284
7-14	Friction Loss in Schedule 40 Plastic Pipe, C=150 (ft/100 ft)	291
7-15	Pipe Materials for Nonpressurized Distribution Networks	297
7-16	Sample Water Balance for Evaporation Lagoon Design	314
8-1	Recommended Ratings for Commercial Grease Traps	324
9-1	Residuals Generated from Onsite Wastewater Systems	339

TABLES (continued)

<u>Number</u>		<u>Page</u>
9-2	Characteristics of Domestic Septage	340
9-3	Indicator Organism and Pathogen Concentrations in Domestic Septage	342
9-4	Land Disposal Alternatives for Septage	345
9-5	Independent Septage Treatment Facilities	340
9-6	Septage Treatment at Wastewater Treatment Plants	350
10-1	Site Evaluati on and System Design Functi ons	359
10-2	Instal lation Functi ons	362
10-3	Operation and Maintenance Functions	364
10-4	Rehabilitation Functi ons	365
A-1	U.S. Department of Agriculture Size Limits for Soil Separates	367
A-2	Types and Classes of Soil Structure	372